Temple at the Nielson Site

Supplemental Geotechnical Engineering Services Report

March 28, 2023 | Terracon Project No. 26235004

Prepared for:

The Haskell Company
111 Riverside Avenue
Jacksonville, Florida 32202

Professional Engineer
GARY W. ROME
4749
Date 3-28-23
WYOMING

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March 28, 2023

The Haskell Company
111 Riverside Avenue
Jacksonville, Florida 32202

Attn: Mr. Aaron Arbuckle, Design Manager
P: (801) 647-6808
E: Aaron.arbuckle@haskell.com

Re: Supplemental Geotechnical Engineering Services Report
Temple at the Nielson Site
Skyline Drive
Cody, Wyoming
Terracon Project No. 26235004

Dear Mr. Arbuckle:

We have completed the scope of Supplemental Geotechnical Engineering Services for the above referenced project in general accordance with the Supplemental Change Order No. 2 – Geotechnical Engineering Services proposal dated January 26, 2023. The approved scope was initiated with a signed Professional Services Agreement Modification No. 001 to Haskell Contract No. 201-006 dated January 31, 2023. This report presents the findings of the supplemental subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements. Parameters are provided for use by others in design of a retaining wall along the north side of the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon

Matthew D. Hoffmann, P.E.
Office Manager

Gary W Rome

Gary Rome, P.E.
Senior Engineer

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Attachments

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our subsurface exploration and Supplemental Geotechnical Engineering Services performed for the proposed new Temple at the Nielson Site to be located at Skyline Drive in Cody, Wyoming. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Lateral earth pressures
- Pavement design and construction
- Stormwater pond considerations (infiltration data)
- Frost considerations

The geotechnical engineering Scope of Services for this project included the advancement of test borings, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and as separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our supplemental geotechnical engineering services change order proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

The preliminary site layout provided by Haskell was located approximately in the same area as the Concept G layout previously provided by DJ&A. The primary change was the inclusion of a planned retaining wall along the northern portion of the parking lot adjacent to the property boundary. This retaining structure is near an area of past slope movement where a deep boring was performed in 2022 to assess slope stability. The global stability of the slope was found to be generally stable without structural loading added to the area, and a setback of 30 feet was recommended. With planned retaining wall development at this area to allow for paving up to this feature, additional subsurface information along the retaining wall alignment was necessary.

Item	Description
Information Provided	Terracon performed a previous geotechnical evaluation and provided a report for the site, Terracon Report No. 26225020, in August 2022. Terracon was requested in November 2022 to develop a proposal to provide supplemental borings for a proposed retaining wall along the north boundary by our client (DJ&A) for the initial geotechnical scope. As the project advanced, we were approached by Haskell (the current engineer for the project) to provide additional supplemental borings (five building borings and five pavement borings) to those proposed for the retaining wall work and updated geotechnical recommendations in an email dated December 9, 2022 from Mr. Arbuckle. At that time, we were provided a supplemental boring layout. On January 17, 2023 we were provided with another updated layout (Drawing C-121-Preliminary Site Plan_geotech markups) showing the desired supplemental boring locations and an additional five infiltration test locations to be added to the scope.
Project Description	We understand the project is to include the construction of a Temple site for the Church of Jesus Christ of Latter-day Saints along with associated parking and landscaping at the site. The development will include auxiliary and utility buildings located on the property as well.
Proposed Structures	It is assumed that the proposed Temple with an approximate footprint on the order of 40,000 square feet is to be a multi-story wood-framed, or light gauge steel construction with brick/masonry veneer. Shallow, frost-depth footings, stem wall, and slab-on-grade construction is assumed for a majority of the building. A basement level will be included in the middle of the building.
Finished Floor Elevation	Not provided at the time of report preparation; however, assumed to be within approximately 2 to 4 feet of existing site grade.
Maximum Loads (assumed)	▪ Wall loads – 4,500 to 7,500 pounds per lineal foot (pfl) ▪ Column loads – 75 to 200 kips ▪ Slab loads – 250 pounds per square foot (psf)

Item	Description
Grading/Slopes	Based on topographic data, it appears that minor grading on the order of 2 to 4 feet will be required to develop final grade at the site. Final slope angles of as steep as 5H:1V (Horizontal: Vertical) surrounding pavement and structures are expected.
Below-Grade Structures	Anticipated basement level on the order of 15 to 20 feet below finished grade.
Free-Standing Retaining Walls	Site grading to require a small retaining wall along north property boundary, approximately 200 feet long. Total height of the wall is anticipated to be less than 5 feet exposed.
Pavements	Paved driveway and parking will be constructed on approximately 1.5 acres of the Temple Area of the parcel. We anticipate that the pavement will generally support passenger vehicles with periodic service trucks. Based on The Church's requirements for new construction of parking lots, we assume the following traffic loading: ▪ Parking: Six 18-kip ESALs per week ▪ Driveways: Fifteen 18-kip ESALs per week ▪ Trash Enclosure Approach Slab: One 40-kip axle load per week Traffic Analysis Period: Asphaltic Concrete Pavement: 40 years
Building Code	IBC 2021

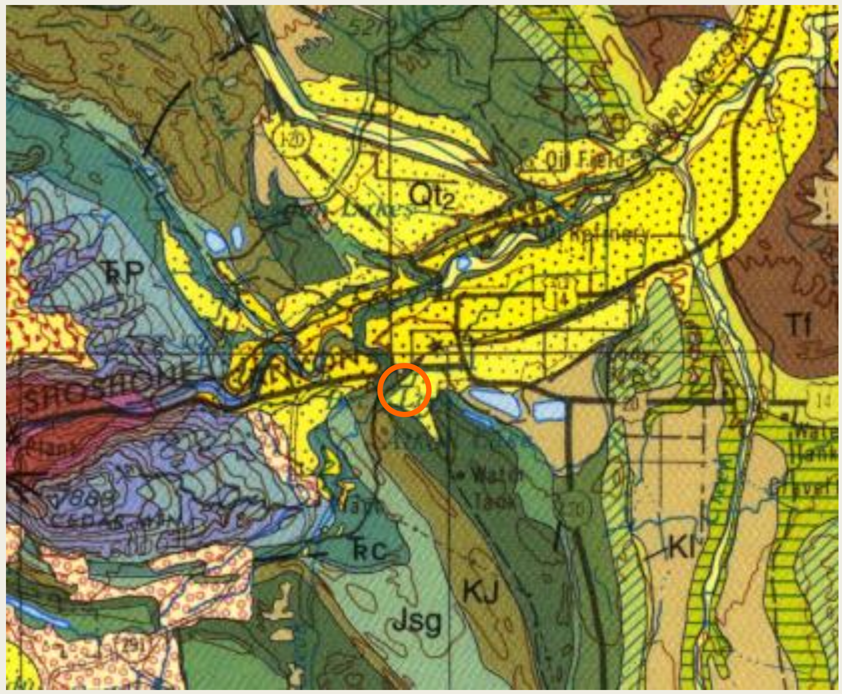
Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located north of the intersection of Skyline Drive with the Cody Canal in Cody, Wyoming. Approximate GPS Coordinates: 44.5119 °N, 109.0819° W See **Site Location**

Item	Description
Existing Improvements	Undeveloped land
Current Ground Cover	Native grasses and isolated areas of bare soil
Existing Topography	The site is situated on a bluff or terrace area with a slight slope along the top of the bluff from south, near Elevation 5142 feet above mean sea level (MSL), toward the north-northeast with a maximum drop of approximately 7 feet based on site specific topographic survey information provided by DJ&A. The north and west sides of the parcel are elevated above low-lying drainage areas feeding Sulfur Creek to the north of the site. The bluff is situated approximately 45 to 90 feet above the low-lying areas to the west and north.

Item	Description
Geology	The site geologic conditions consist primarily of medium dense to very dense alluvial gravel terrace deposits with varying amounts of silt and sand. These deposits are underlain by Cretaceous Age interbedded sandstone and claystone bedrock with historically reported bentonite beds anticipated within the variegated claystone.  **Figure 1: Excerpt from Geologic Map of the Cody 1° x 2° Quadrangle, Northwestern Wyoming (compiled by William G. Pierce, 1997)**

We also collected photographs at the time of our field exploration program. Representative photos are provided in our **Photography Log**.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** and the GeoModel can be found in the **Figures** attachment of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Upper Gravel**	Well-Graded GRAVEL with Silt and Sand OR Silty Gravel with Sand, fine grained, subangular, light brown, dry, medium dense
2	**Lower Gravel**	Poorly-Graded GRAVEL with Silt and Sand, coarse grained, subrounded, light brown to gray, dry, medium dense to very dense, some cobbles
3	**Clay**	Sandy Fat CLAY, medium to high plasticity, brown, moist, stiff to very stiff
4	**Bedrock**	CLAYSTONE, tan, moist, fine-grained, moderately fractured, thin bedding, highly weathered, weak rock, interbedded sandstone layer

The borings were advanced in the dry using an air rotary drilling technique that allows short term groundwater observations to be made while drilling. Groundwater seepage was not encountered within the maximum drilling depth at the time of our field exploration, which was conducted in February 2023. Groundwater conditions may be different at the time of construction. Groundwater conditions may change because of seasonal variations in rainfall, runoff, and other conditions not apparent at the time of drilling. Long-term groundwater monitoring was outside the scope of services for this project.

Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil/bedrock properties observed at the site and as described on the exploration logs and results, our professional opinion is for that a **Seismic Site Classification of C** be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 41.5 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

Percolation/Infiltration

Terracon performed the infiltration testing on February 13, 2023. The infiltration testing was performed in general accordance with the City of Cody Public Works requirements at five locations as directed by Haskell. Preparation of the infiltration test was begun by drilling a hole to the depth of approximately 10 feet per the direction of Haskell civil design team using 10" outside diameter hollow stem augers at the locations shown as I-1 through I-5 on the attached Exploration Plan. Two inches of gravel was placed at the bottom of the hole then a perforated PVC pipe (ten feet in length and four inches in diameter) was placed inside the hollow stem augers. The exterior of the PVC pipe was filled with coarse gravel prior to the removal of the hollow stem augers. Eighteen inches of water was added inside the PVC pipe for the soaking period, which generally percolated within 20 minutes at all locations. A second 18 inches was then placed in each percolation hole, and again the water percolated out of the location within approximately 20 minutes or less. The testing then began with 12 inches of water placed in the holes and due to the speed of infiltration, readings were taken at 30-second intervals to obtain the data. This was conducted three separate times in each hole to develop the test rates provided in the table below:

Table 1: Infiltration Rate Summary Table

Location	Depth (feet)	Material Encountered	Test Rate (min/in)
I-1	10	Poorly-Graded Gravel with Silt and Sand (GP-GM)	1.0
I-2	10	Poorly-Graded Gravel with Silt and Sand (GP-GM)	0.5
I-3	10	Poorly-Graded Gravel with Silt and Sand (GP-GM)	1.3
I-4	10	Poorly-Graded Gravel with Silt and Sand (GP-GM)	1.0
I-5	10	Poorly-Graded Gravel with Silt and Sand (GP-GM)	0.5

A design rate should be selected by the designer by applying an appropriate factor of safety to the field infiltration rate presented above. With time, the bottoms of infiltration systems tend to clog with organics, sediments, and other debris. Long-term maintenance will be required to help reduce clogging and maintain the designed infiltration rate of the systems. The infiltration rate may have been affected by the following factors, which should be considered when selecting the factor of safety:

- The infiltration test was conducted in a 10-inch diameter borehole. The infiltration rates in large storm water infiltration systems may be different than the infiltration rate measured in the relatively small 10" borehole.
- The infiltration test was conducted using relatively clean water. However, the storm water will likely not be clean and may contain organics, fines, and contaminations. The presence of these materials will tend to decrease the rate that the water will percolate from the infiltration systems. The design of the stormwater infiltration systems should account for the water quality and should incorporate structures/devices to remove these materials in the water.

Based on the soils encountered during our exploration, we expect the infiltration rates of the soils to vary between multiple areas due to the variations in the soil types. Infiltration into the soils with a higher percentage of fines would be expected to have slower infiltration rates. The design elevations and sizes of the proposed infiltration systems should account for this expected variability in the infiltration rate.

Corrosivity

The table below lists the results of laboratory soluble sulfate, electrical resistivity, and pH testing for a select sample of native soils that would be within the potential backfill/retained zone of the retaining wall planned for the north side of the site. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary

Boring	Sample Depth (feet)	Soil Description	Soluble Sulfate (%)	Electrical Resistivity (Ω-cm)	pH
RW-3	2.5-4.0	Silty Gravel with Sand (GM)	0.109	407	7.5

Results of soluble sulfate testing can be classified in accordance with ACI 318 – Building Code Requirements for Structural Concrete. Numerous sources are available to characterize corrosion potential to buried metals using the parameters above. ANSI/AWWA is commonly used for ductile iron, while threshold values for evaluating the effect on steel can be specific to the buried feature (e.g., piling, culverts, welded wire reinforcement, etc.) or agency for which the work is performed. Imported fill materials may have significantly different properties than the site materials noted above and should be evaluated if expected to be in contact with metals used for construction.

Consultation with a NACE certified corrosion professional is recommended for buried metals on the site.

Geotechnical Overview

A supplemental geotechnical exploration has been performed for the proposed new Temple at the Nielson Site in Cody, Wyoming. A total of 14 borings were drilled to depths ranging between 10.4 to 11.5 feet below existing grade for pavements, 18.0 to 41.5 feet below existing grade for the building, and 21.5 feet below existing grade for evaluation of the retaining wall foundation area on the north portion of the site. This report addresses the geotechnical recommendations for foundations along with earthwork portions and pavement construction for the project.

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test borings, provided that the recommendations provided in this report are implemented in the design and construction phases of this project.

The predominant subsurface materials are gravel soils with varying amounts of fines along with isolated zones of medium to high plasticity sandy fat clay in the upper 8.0 feet of the profile on the south side of the property, along the planned new access road/cul-de-sac. The soil profiles are presented in further detail on the attached GeoModel, which can be found in the **Figures** section of the report, along with on the individual Boring Logs within the **Exploration Results** section of this report. Groundwater was not encountered within the maximum depths of exploration during or at the completion of drilling.

Based on the conditions encountered and estimated load-settlement relationships, the proposed structures can be supported on conventional continuous or spread footings bearing on properly prepared native gravel soils.

The near surface soils consist primarily of gravels, with an area of lean clay with gravel located along the eastern portion of the site. The gravel soils are expected to provide stable subgrade conditions for construction of planned improvements. The clay soils, where encountered, could become unstable with typical earthwork and construction traffic, especially after precipitation events. The establishment of effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. If possible, the grading should be performed during the warmer and drier times of the year. If grading is performed during the winter months, an increased risk for possible undercutting and replacement of unstable subgrade will persist. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the **Earthwork** section.

The soils which form the bearing stratum for shallow foundations are medium dense to very dense alluvial terrace gravel deposits, which provide reliable support with limited potential for differential settlement when properly prepared. The **Shallow Foundations** section addresses support of the building bearing on properly prepared native granular soils. The **Floor Slabs** section addresses slab-on-grade support of the building.

Our opinion of pavement section thickness design has been developed based on our understanding of the intended use, assumed traffic, and subgrade preparation recommended herein using methodology contained in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993) and adjusted with consideration to local practice. The **Pavements** section includes minimum pavement component thickness.

Based on our previous study conducted at the site, past slope instabilities appear to have occurred at the northern portion of the site. An obvious past slope failure lobe, generally moving in the direction of Sulfur Creek from the bluff site, was noted in this review, and supplemental borings were placed along the proposed alignment of a retaining wall at this location. Based on subsurface conditions encountered consisting of medium dense to very dense gravel deposits overlying interbedded claystone and sandstone bedrock, global stability of the slope is not of concern. The retaining wall design to be completed by Haskell should include parameters as provided in the **Below-Grade Structures** and **Lateral Earth Pressures** sections of this report.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Site Preparation

Prior to placing fill, existing vegetation, root mat, and existing fill should be removed. Complete stripping of these materials should be performed in the proposed building and parking/driveway areas.

For foundations, excavations should be conducted to base of footing elevation, at which elevation native gravel subgrade should be moisture conditioned and compacted to a minimum of 98 percent of the maximum laboratory dry density per ASTM D698 prior to placement of foundation concrete.

After removal of vegetation and any unsuitable materials, the pavement subgrade areas should be scarified to a depth of 12 inches and recompacted to 95 percent of the maximum dry density per ASTM D698 to improve loose or soft areas. After scarifying and re-compacting, the pavement subgrade should be subsequently proofrolled with an adequately loaded vehicle such as a fully-loaded tandem-axle dump truck with a minimum weight of 20 tons and tire pressures on the order of 90 psi. The proofrolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting, yielding, pumping, or rutting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer. Excessively wet or dry material should either be removed or moisture conditioned and recompacted.

Where fill is placed on existing slopes steeper than 5H:1V, benches should be cut into the existing slopes prior to fill placement. The benches should have a minimum vertical face height of 1 foot and a maximum vertical face height of 3 feet and should be cut wide enough to accommodate the compaction equipment. This benching will help provide a positive bond between the fill and natural soils and reduce the possibility of failure along the fill/natural soil interface.

Interior slabs-on-grade should be prepared in accordance with the **Floor Slabs** section recommendations subsequently discussed within this report. Exterior slabs-on-grade (flatwork) should be prepared consistent with pavement subgrade as discussed above.

Excavation

We anticipate that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. The bottom of excavations should be thoroughly cleaned of loose soils and disturbed materials prior to backfill placement and/or construction.

Fill Material Types

Fill required to achieve design grade should be classified as Structural Fill, Select Fill, and General Fill. Structural Fill (if required) is material used below foundations, or within 5 feet horizontally of structures, or pavements. Select Fill is optional material for use from native prepared subgrade to within 6 inches of base of interior floor slabs, where the use of Structural Fill gradations is not strictly required. General fill is material used to achieve grade outside of these areas. Earthen materials used for structural and general fill should meet the following material property requirements:

Reuse of On-Site Soil: Excavated on-site granular soil may be selectively reused as fill below pavement and landscaping areas, and as exterior backfill of foundations. The on-site fat clay soils are not recommended for reuse on site due to the potential difficulties in moisture conditioning and compacting these materials which are sensitive to moisture conditions.

Material property requirements for on-site soil for use as general fill and Structural Fill are noted in the table below:

Property	General Fill	Structural Fill
Composition	Free of deleterious material	Free of deleterious material
Maximum particle size	6 inches (or 2/3 of the lift thickness)	3 inches
Fines content	Not limited	Less than 12% Passing No. 200 sieve
Plasticity	Not limited	Maximum plasticity index of 10
GeoModel Layer Expected to be Suitable[1]	1, 2	1, 2

1. Based on subsurface exploration. Actual material suitability should be determined in the field at time of construction.

Imported Fill Materials: Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Structural Fill[2] (imported material)	GW, GP, SW, SP, and dual (GM/SM) symbols	Below foundation elevation, below slab areas, and as replacement backfill
Select Fill[3] (sub-slab areas above footing elevation)	GW, GP, SW, SP and dual (GM/SM) symbols	Below slab areas, interior utility trench backfill, above foundation/footing elevation (option to replacement using Structural Fill)

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Crushed Base Course	1 ½ inch minus, Wyoming Public Works Standard Specifications (WPWSS) Section 02190, Grading W	Leveling course below slab above Structural or Select Fill, and as crushed aggregate base course for pavements
General Fill [4]	ML, CL, CL-ML, SM, SP	The on-site gravels and lean clay with gravel soils appear suitable for use as General Fill, including site grade raising material, site (exterior) utility trench backfill, and exterior backfill of foundations.
Non-Frost Susceptible Fill (NFS) [5]	GP, GW, SP, SW	Below exterior flatwork critical to project to mitigate frost-action

1. Structural, Select, and General Fill should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. Structural Fill, defined as imported aggregate, should meet the following criteria outlined below:

Gradation	Percent Finer By Weigh (ASTM C136)
1 ½"	100
No. 4	30-60
No. 200 12 (max)	
Liquid Limit	25 (max)
Plastic Index	10 (max)

3. Select Fill, defined as imported aggregate, should meet the following criteria outlined below:

Gradation	Percent Finer By Weigh (ASTM C136)
3"	100
No. 4	80
No. 40	35
No. 200 15 (max)	
Liquid Limit	30 (max)
Plastic Index	10 (max)

4. Significant moisture conditioning of the native clay may be necessary to meet compaction requirements; this will require mechanical reduction in clay clod size (i.e. disking, etc.) to a maximum 1-inch dimension to facilitate moisture conditioning; the necessary moisture adjustment will be difficult during wet/cold seasons.
5. Non-Frost Susceptible Fill should have no more than 5 percent passing the No. 200 sieve

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	Select Fill	General Fill
Maximum Lift Thickness	9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used	Same as Structural Fill	Same as Structural Fill
Minimum Compaction Requirements [1,2]	98% of max. below foundations, interior floor slabs, and interior backfill (including building utility trench backfill) 95% of max. above foundations, exterior backfill, and below pavements City Street requirements change to 95% of max. as determined by modified Proctor test (AASHTO T180) for base course and 90% for subbase course	98% of max. below floor slabs	92% of max. in green areas
Water Content Range [1]	Low plasticity cohesive: -2% to +3% of optimum Granular: -3% to +3% of optimum	Granular: -3% to +3% of optimum	As required to achieve min. compaction requirements

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254). Materials not amenable to density testing should be placed and compacted to a stable condition observed by the Geotechnical Engineer or representative.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with Structural Fill or bedding material in accordance with public works specifications for the utility be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1H:1V (Horizontal : Vertical) projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site materials are considered suitable for backfill of utility and pipe trenches from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the gradation requirements of engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5% away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as floor slabs and pavements. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our scope of services does not include review of available final grading information or consider potential temporary grading performed by the contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil, and rootmats), evaluation and remediation of existing fill materials, as well as proofrolling and mitigation of unsuitable areas delineated by the proofroll.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas. Where not specified by local ordinance, one density and water content test should be performed for every 100 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

The primary geotechnical consideration for the Temple site is to provide uniform bearing within the native gravel while limiting potential for differential settlement. To accomplish this, proper preparation of the native gravel subgrade in accordance with the requirements noted in **Earthwork** is critical to limiting differential movement, as the gravel soils provide substantial bearing capacity for the type of building construction planned. The following design parameters are applicable for shallow foundations if the requirements of the **Earthwork** section are adhered to.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	3,500 psf
Required Bearing Stratum [3]	Properly prepared native gravel, or Structural Fill replacement fill
Minimum Foundation Dimensions	Per IBC 1809.7
Ultimate Passive Resistance[4] **(equivalent fluid pressures)**	190 pcf (cohesive backfill) 460 pcf (granular backfill)
Ultimate Coefficient of Sliding Resistance [5]	0.60 coefficient of friction - granular material
Minimum Embedment below Finished Grade [6]	Exterior footings in unheated areas: 48 inches Interior footings in heated areas: 18 inches

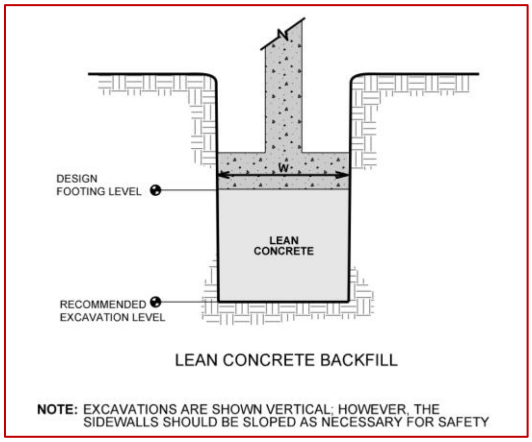
Item	Description
Estimated Total Settlement from Structural Loads [2]	Less than about ¾ inch
Estimated Differential Settlement [2, 7]	About ½ to $^{2}/_{3}$ of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Values assume that exterior grades are no steeper than 20% within 10 feet of structure. Based on a minimum factor of safety of 3.
2. Values provided are for maximum loads noted in **Project Description**. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in **Earthwork**.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted Structural Fill be placed against the vertical footing face. Assumes no hydrostatic pressure. A minimum factor of safety of 2 should be applied to ultimate values.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance for granular materials is dependent on the bearing pressure which may vary due to load combinations. For fine-grained materials, lateral resistance using cohesion should not exceed ½ the dead load, also application of a minimum factor of safety of 2 should be utilized.
6. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
7. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet.

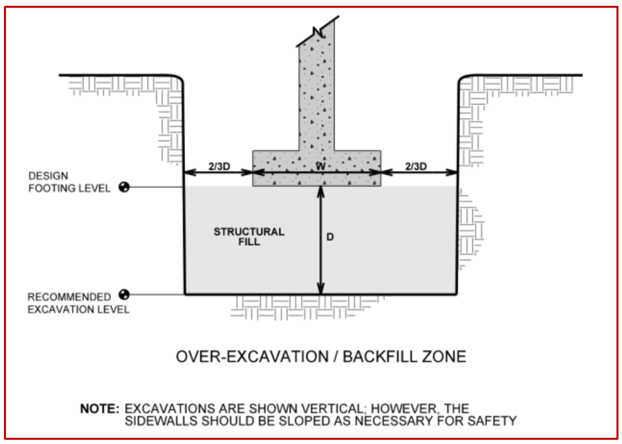
Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are observed at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. The lean concrete replacement zone is illustrated on the sketch below.



Overexcavation for Structural Fill placement below footings should be conducted as shown below. The overexcavation should be backfilled up to the footing base elevation, with Structural Fill placed and compacted as recommended in the **Earthwork** section.



Floor Slabs

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support[1,2]	Properly prepared native gravel or Structural Fill replacement material below a minimum of 6 inches of crushed base course Subgrade compacted to recommendations in **Earthwork**

Item	Description
Estimated Modulus of Subgrade Reaction [3]	250 pounds per square inch per inch (psi/in) for point loads

1. Crushed aggregate base course in accordance with Wyoming Public Work Standard Specifications, Section 02190, Grading W.
2. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
3. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, when the project includes humidity-controlled areas, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual. Joints or cracks should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and Structural Fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Below-Grade Structures

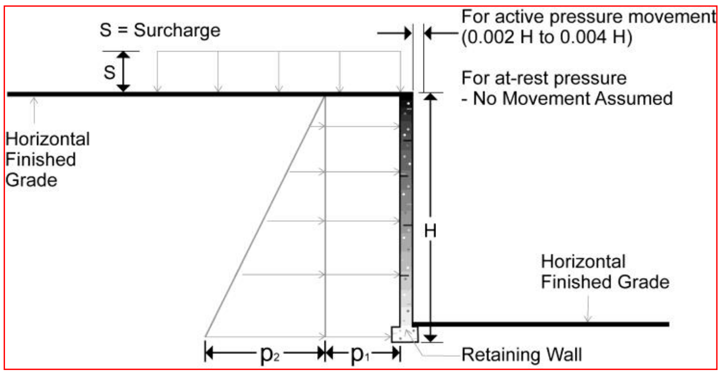
It is our understanding that a basement level, approximately 15 to 20 feet below finished grade, will be included below the main portion of the temple. This basement level will likely include placement of slab-on-grade floor and will be deep enough that it is likely to act as a compensated foundation. That is, the added stress from the structure (foundation and/or slab) will be less than the overburden pressure from the soil removed. Therefore, settlement of the foundations will be largely dependent upon earthwork quality and removal of loose material. Recompacting of subgrade will be important to overall performance. Inclusion of water stop between exterior footings and exterior foundation walls should be included in the design to reduce the potential for surface infiltrated moisture to enter the below grade spaces at the construction joint.

Lateral Earth Pressures

We understand that a retaining wall is planned along the north portion of the site to allow for pavement of the area near the past slope instability/slump feature. Based on our slope stability analysis, the gravel slope in the vicinity of the failure is stable in a global stability model. The use of the retaining wall will be required to provide a nominal 4 to 5 feet of fill for site grading to allow for use of the area for pavements and landscaping. Based on the global stability, the design of a retaining wall should include the following lateral earth parameters as well as embedment to a depth of no less than 7.5 feet below existing grade to provide bearing support within the lower dense to very dense gravel layer to keep global stability factors of safety above 1.5. Bearing capacity at this depth will be at least 3,500 psf for foundation bearing of the wall system. This will allow for substantial embedment on the downslope side of the retaining wall, and the internal stability of the design will need to be evaluated by Haskell. Terracon will need to review the final design to check for consistency of design with the parameters provided, as required by our contract.

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction, and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters

Earth Pressure Condition [1]	Coefficient for Backfill Type [2]	Surcharge Pressure [3] p_1 (psf)	Equivalent Fluid Pressures (psf) [2,4,5]
Active (Ka)	Native Upper Gravel - 0.33 Imported Structural Fill - 0.27	(0.33)S (0.27)S	(40)H (35)H
At-Rest (Ko)	Native Upper Gravel - 0.50 Imported Structural Fill - 0.43	(0.50)S (0.43)S	(65)H (55)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance. Fat clay or other expansive soils should not be used as backfill behind the wall.
2. Uniform, horizontal backfill, with a maximum unit weight of 125 pcf for native upper gravel soils and 130 pcf for Structural Fill (imported).
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. To achieve "Unsaturated" conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below.

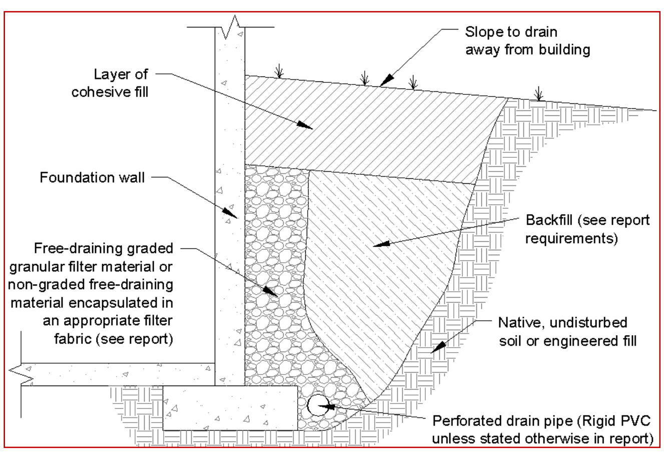
Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 degrees from vertical for the active case.

Footings, floor slabs or other loads bearing on backfill behind walls may have a significant influence on the lateral earth pressure. Placing footings within wall backfill and in the zone of active soil influence on the wall should be avoided unless structural analyses indicate the wall can safely withstand the increased pressure.

The lateral earth pressure recommendations given in this section are applicable to the design of rigid retaining walls subject to slight rotation, such as cantilever, or gravity type concrete walls. These recommendations are not applicable to the design of modular block - geogrid reinforced backfill walls (also termed MSE walls). Recommendations covering these types of wall systems are beyond the scope of services for this assignment. However, we would be pleased to develop a proposal for evaluation and design of such wall systems upon request.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a prefabricated drainage structure may be used. A prefabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

Pavements

General Pavement Comments

The pavement section recommendations provided are based on the subsurface profile and laboratory testing of bulk samples obtained from the subgrade encountered during our field exploration. Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the **Earthwork** section. The pavement section recommendations provided below are suitable for traffic support as discussed within each section upon the fully constructed pavement section. These sections, or portions of the constructed section, have not been designed to support channelized and high-intensity traffic loading associated with construction traffic such as concrete trucks for placements, aggregate or asphalt haul trucks.

Pavement Design Parameters

Designs for minimum thicknesses for new pavement sections for this project have been based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993). Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of subgrade soils. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade.

To analyze pavement subgrade support, a composite bulk sample was obtained throughout the anticipated pavement areas. The controlling subgrade material (alluvial deposits, generally classified as clayey sand with gravel) was collected and laboratory-soaked CBR performed at a single point condition during our previous exploration conducted at this site. The single point soaked California Bearing Ratio (CBR) condition resulted in a value of 8.0 for the controlling subgrade which was utilized in the analysis discussed below.

Our analysis has been conducted assuming the minimum required traffic based on The Church's requirements for new construction of parking lots. We expect that primary traffic will consist of passenger vehicles with substantial personal auto/light trucks along with limited daily light delivery vehicles (FedEx, UPS, similar) and with weekly trash collection. We have assumed that the combined traffic can be considered in two scenarios, Light Duty for parking and areas of limited traffic and Medium Duty for areas of more substantial drive lane traffic. For these cases we have assumed a total load coverage equivalent of approximately six weekly 18-kip single axle loads (ESALs) for Light Duty and 15 weekly ESALs for Medium Duty. Based on these assumptions, an estimated 30,000 ESALs represent the design traffic intensity for Light Duty pavements and an estimated 60,000 ESALs represent the design traffic intensity for Medium Duty pavements over an approximate 40-year design period. For analysis an initial serviceability index of 4.2, a terminal serviceability index of 2.0, standard deviation of 0.45, and reliability of 90 percent have been utilized for section thickness development.

A modulus of subgrade reaction of about 150 pci was used for the PCC pavement designs. The values were based upon the controlling CBR value of 8.0 and correlated to k-value for rigid pavement design based on published data and our experience with the clayey sand subgrade soils and our understanding of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in **Earthwork**. A modulus of rupture of 580 psi was used for pavement concrete.

Pavement Subgrade Preparation

For all areas to receive new asphalt pavement sections, we recommend that the upper 12 inches of the subgrade be scarified, moisture conditioned and compacted to 95 percent of the maximum laboratory dry density value in accordance with ASTM D698 prior to placement of pavement section components. The subgrade should be evaluated and tested for compliance with these conditions within 24 hours of commencement of pavement operations to ensure that the moisture content and density values are within recommended ranges. Areas not in compliance should be moisture conditioned and recompacted. Areas where unsuitable conditions (as delineated by proof-rolling subsequent compaction testing) are located should be repaired either by reworking the existing soil or removing and replacing the soil with properly compacted fills. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by a qualified individual immediately prior to placement of base course. The subgrade should be in its finished form at the time of the final review.

Pavement Section Thicknesses

The following table provides our opinion of minimum thickness for AC sections:

Asphaltic Concrete Design

Layer	Thickness (inches)		
	Light Duty [1]	Medium Duty [2]	Specifications
Subgrade	Upper 12 inches of existing soil	Upper 12 inches of existing soil	95% of maximum dry density per ASTM D698, +/-3% of Optimum Moisture Content (OMC)
Crushed Base Course	8	9	WPWSS, Section 02190, Grading W
Asphalt Concrete	3	4	WPWSS, Section 02510
Total Pavement Section	11	13	--

1. Light Duty Pavement was designed for a total of 30,000 ESALs.
2. Heavy Duty Pavement was designed for a total of 60,000 ESALs.

We recommend that Portland cement concrete (PCC) pavement be utilized in entrance and exit sections, dumpster pads, and other areas where extensive wheel maneuvering is expected. Heavy duty pavement design for the apron was based on 60,000 ESALs. The following table provides our estimated minimum thickness of PCC pavements.

Portland Cement Concrete Design

Layer	Thickness (inches)	
	Thickness (inches)	Specifications
Subgrade	Upper 12 inches of existing soil	95% of maximum dry density per ASTM D698, +/-3% of Optimum Moisture Content (OMC)
Crushed Base Course	4	WPWSS, Section 02190, Grading W
PCC (reinforced)	6	WPWSS, Section 02520
Total Pavement Section	10	--

Although not required for structural support, a minimum 4-inch thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign material and doweled where necessary for load transfer. PCC pavement details for joint spacing, joint reinforcement, and joint sealing should be prepared in accordance with ACI 330 and ACI 325.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. Islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils are particular areas of concern. The civil design for the pavements with these conditions should include features to restrict or collect and discharge excess water from the islands. Examples of features are edge drains connected to the stormwater collection system, longitudinal subdrains, or other suitable outlets and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

The Portland cement concrete mix design should be designed with proper air-entrainment and have a minimum compressive strength of 4,000 psi after 28 days of laboratory curing. Adequate reinforcement and number of longitudinal and transverse control joints should be placed in the rigid pavement in accordance with ACI requirements. The joints should be sealed as soon as possible (in accordance with the sealant manufacturer's instructions) to minimize infiltration of water into the soil.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Pavement care consists of both localized (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Additional engineering consultation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

Frost Considerations

The gravel soils located on the site have limited frost susceptibility; however, the clay soils located near the east side (from the previous site exploration) of the site to depths between 1.5 and 2.0 feet below existing grade and the clay soils located along the south access road to depths between 4.0 and 7.5 feet below existing grade are frost susceptible. Where clay subgrades are encountered small amounts of water can affect the performance of the slabs on-grade, sidewalks, and pavements. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be eliminated in critical areas, we recommend the use of non-frost susceptible (NFS) fill or structural slabs (for instance, structural stoops in front of building doors). Placement of NFS material in large areas may not be feasible; however, the following recommendations are provided to help reduce potential frost heave:

- Provide surface drainage away from the building and slabs, and toward the site drainage system.
- Install drains around the perimeter of the building, stoops, below exterior slabs and pavements, and connect them to the site drainage system.
- Grade clayey subgrades so groundwater potentially perched in overlying fill or aggregate base, slope toward a site drainage system.
- Place NFS fill as backfill beneath slabs and pavements critical to the project.
- Place a 3 horizontal to 1 vertical (3H:1V) transition zone between NFS fill and other soils.
- Place NFS materials in critical sidewalk areas.

As an alternative to extending NFS fill to the full frost depth, consideration can be made to placing extruded polystyrene or cellular concrete under a buffer of at least 2 feet of NFS material.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

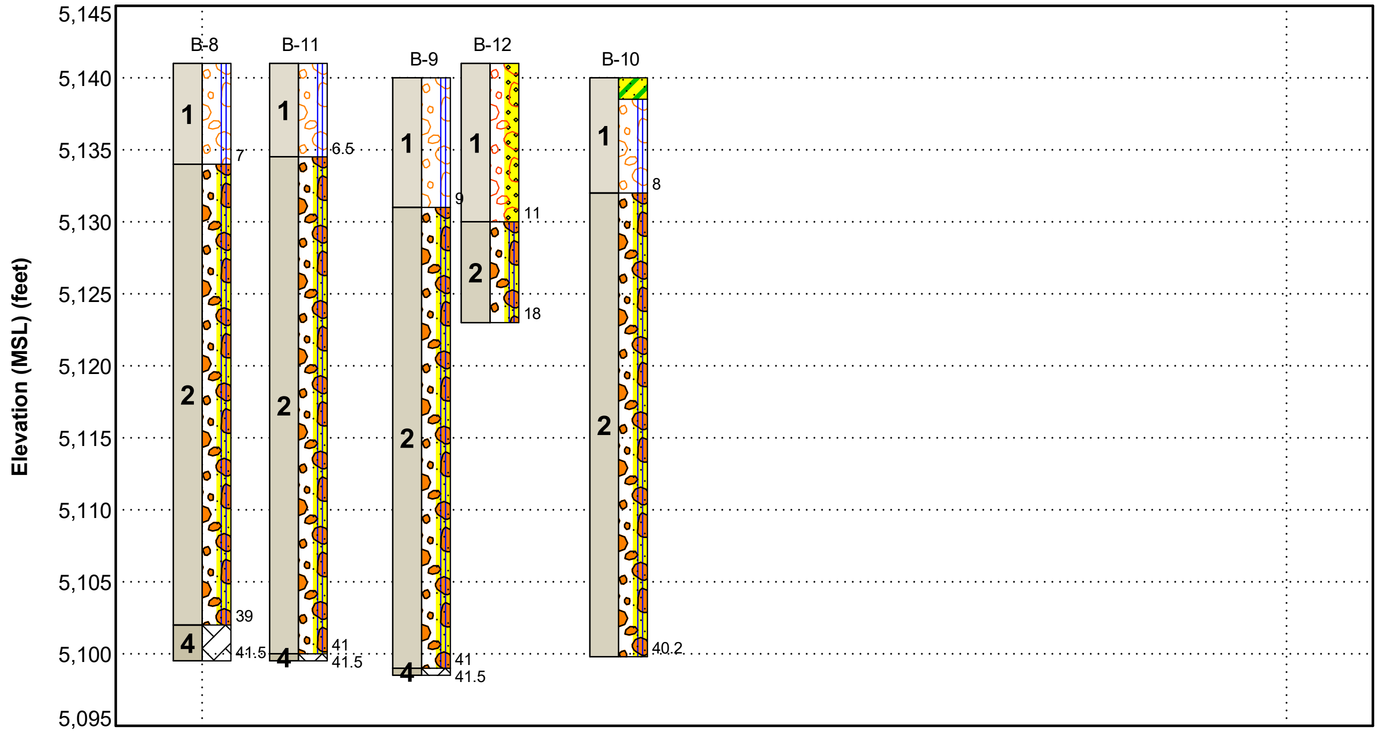
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly effect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Figures

Contents:

2110 Overland Ave Ste 124
Billings, MT

GeoModel - Building Area



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Upper Gravel	Well-Graded GRAVEL with Silt and Sand OR Silty Gravel with Sand, fine grained, subangular, light brown, dry, medium dense
2	Lower Gravel	Poorly-Graded GRAVEL with Silt and Sand, coarse grained, subrounded, light brown to gray, dry, medium dense to very dense, some cobbles
3	Clay	Sandy Fat CLAY, medium to high plasticity, brown, moist, stiff to very stiff
4	Bedrock	CLAYSTONE, tan, moist, fine-grained, moderately fractured, thin bedding, highly weathered, weak rock, interbedded sandstone layer

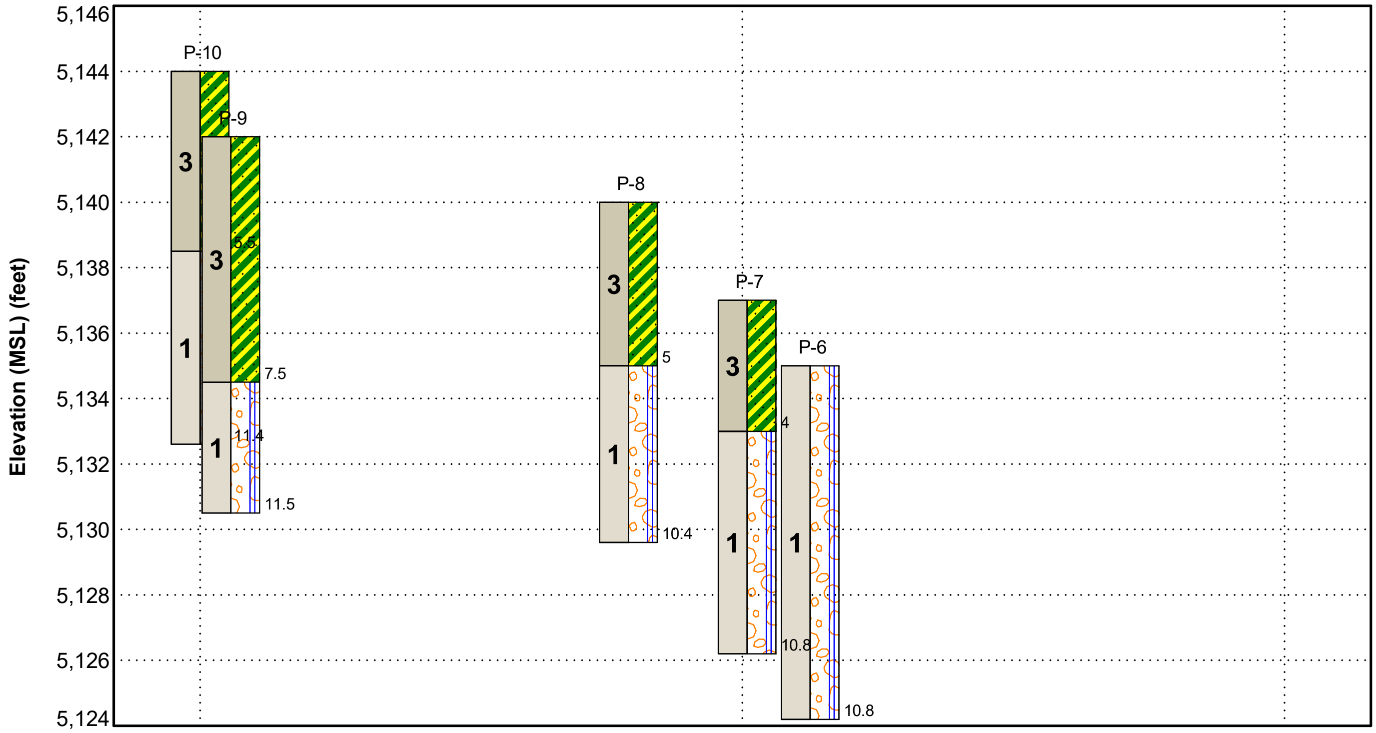
LEGEND

- Clayey Sand
- Claystone
- Well-graded Gravel with silt
- Well-graded Gravel w/sand
- Poorly-graded Gravel with Silt and Sand

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

2110 Overland Ave Ste 124
Billings, MT

GeoModel - Pavement Area



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LEGEND

Sandy Fat Clay

Well-graded Gravel with silt

NOTES:

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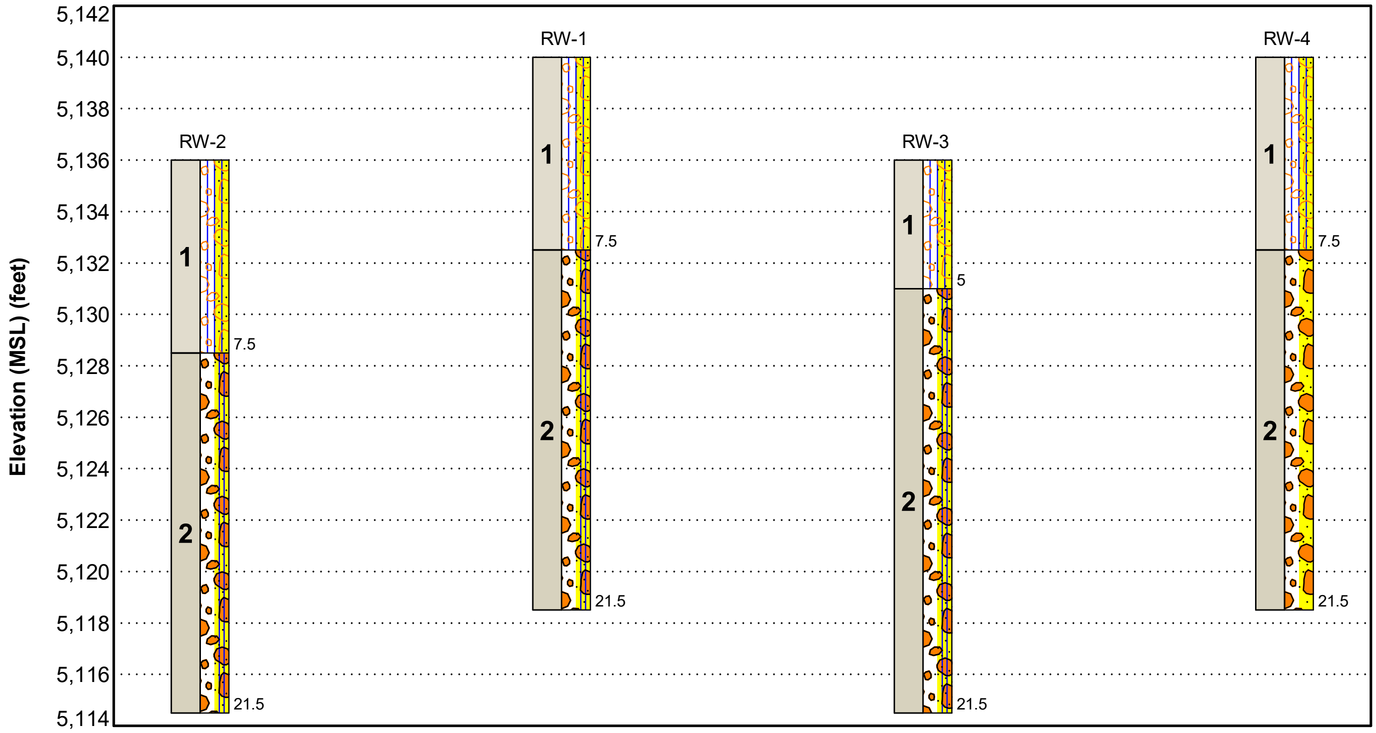
2110 Overland Ave Ste 124
Billings, MT

GeoModel - Retaining Wall



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Model Layer	Layer Name	General Description
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3	Clay	Sandy Fat CLAY, medium to high plasticity, brown, moist, stiff to very stiff
4	Bedrock	CLAYSTONE, tan, moist, fine-grained, moderately fractured, thin bedding, highly weathered, weak rock, interbedded sandstone layer

LEGEND

- Silty Gravel with Sand
- Poorly-graded Gravel with Silt and Sand
- Poorly-graded Gravel with Sand

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
5	18.0 to 41.5	Building Area
5	10.4 to 11.5	Pavement Areas
4	21.5	Retaining Wall Alignment

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features. Approximate ground surface elevations were estimated using Google Earth. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings between February 14 and February 17, 2023, using a subcontracted truck-mounted, rotary drill rig operated by Haztech Drilling of Billings, Montana using continuous flight augers (hollow stem). In general, four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Bulk samples were collected in the upper 5 feet of the borings, as needed. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge was pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Other Testing: In addition to the borings outlined in the table above, we performed percolation tests, indicated by the designation I-1 through I-5 on the Exploration Plan, in general accordance with the City of Cody Public Works requirements at five locations on the site. The results of the percolation tests are summarized and provided with the exploration results below.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Dry Unit Weight
- Consolidation/Swell
- Unconfined Compression
- Atterberg Limits

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Rock classification was conducted using locally accepted practices for engineering purposes; petrographic analysis may reveal other rock types. Rock core samples typically provide an improved specimen for this classification. Boring log rock classification was determined using the Description of Rock Properties.

Other Testing: Soil analytical testing for water soluble sulfate, resistivity, and pH were performed by Energy Laboratories in Billings, Montana. Results are attached.

Photography Log

View looking East from Boring B-9

View looking North from Boring B-9

View looking South from Boring B-9

View looking West from Boring B-9

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

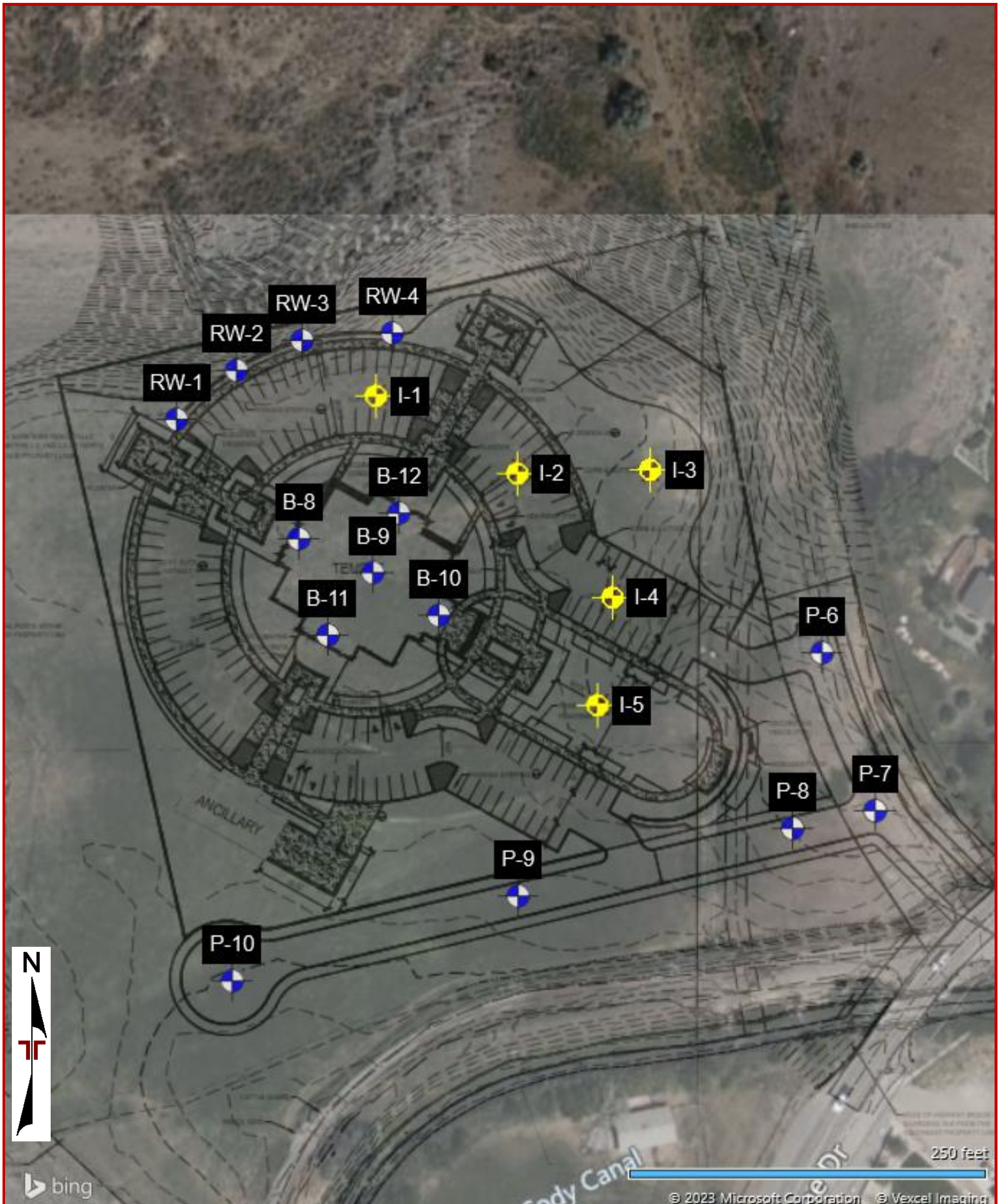


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Boring Logs (B-8 through B-12, P-6 through P-10, and RW-1 through RW-4)
Atterberg Limits
Grain Size Distribution (2 pages)
Consolidation/Swell
Unconfined Compressive Strength
Corrosivity (7 pages)

Note: All attachments are one page unless noted above.

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-8

Location: See Exploration Plan

Latitude: 44.5118° Longitude: -109.0822°

Model Layer	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, moist, medium dense to dense, homogeneous			X	6-6-7 N=13				15.6		
					X	11-16-14 N=30				2.7		
			5		X	11-9-10 N=19				3.1		NP
	7.0											
2		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous			X	16-25-25 N=50				3.7		
			10		X	33-42-50/5"				3.5		
			15		X	50/5"				4.0		
			20		X	50/1"						
			25									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations were obtained from Google Earth

Water Level Observations

None Observed

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-14-2023

Boring Completed
02-14-2023

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-8

Location: See Exploration Plan

Latitude: 44.5118° Longitude: -109.0822°

Model Layer	Graphic Log	Depth (Ft.) / Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	
2		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous *(continued)*			X	14-27-41 N=68				8.6			
			30		X	22-37-50/4"				5.2			
			35		X	50/5"				10.5			
		39.0											
4		**CLAYSTONE**, tan, dry, fine-grained, moderately fractured, close fracture spacing, thin bedding, highly weathered, weak rock, trace of gravel and sand	40		X	10-10-26 N=36				25.1			
		41.5											

Boring Terminated at 41.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
TJ Trussell

Boring Started
02-14-2023

Boring Completed
02-14-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-9

Location: See Exploration Plan

Latitude: 44.5117° Longitude: -109.0820°

Model Layer	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (psf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, moist, medium dense to dense, homogeneous				6-8-9 N=17				12.3		
						14-22-19 N=41				3.6		
			5			10-11-12 N=23				2.3		
						14-16-16 N=32				2.7		
2	9.0	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous	10			15-50/4"				3.2		
			15			23-50/5"				3.1		
			20			50/5"						
			25									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
TJ Trussell

Boring Started
02-15-2023

Boring Completed
02-15-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-9

Location: See Exploration Plan

Latitude: 44.5117° Longitude: -109.0820°

Model Layer	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (psf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
2		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous *(continued)*				16-15-27 N=42				5.9		
			30			20-50/5"				6.2		
			35			18-28-33 N=61				5.1		
	41.0		40			21-26-20 N=46				5.8		
4	41.5	**CLAYSTONE**, tan, dry, fine-grained, moderately fractured, close fracture spacing, thin bedding, highly weathered, weak rock, trace of gravel and sand										

Boring Terminated at 41.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
TJ Trussell

Boring Started
02-15-2023

Boring Completed
02-15-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-10

Location: See Exploration Plan

Latitude: 44.5116° Longitude: -109.0818°

Model Layer	Depth (Ft.)	Material Description	Sample Depth (Ft.)	Field Test Results	Test Type	Compressive Strength (psf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1	0 - 1.5	**CLAYEY SAND (SC)**, fine grained, brown, moist, loose to medium dense, homogeneous	0 - 1.5	8-5-3 N=8				17.7		35-24-11
1	1.5 - 8.0	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, moist, medium dense to dense, homogeneous	2.5 - 4.0	8-14-11 N=25				6.4		
			5.0 - 6.5	7-9-19 N=28				3.4		
2	8.0 - 25	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous	7.5 - 9.0	12-23-26 N=49				3.1		
			10	50/5"				3.8		
			15	50/5"				3.5		
			20 - 21.5	12-28-40 N=68				5.5		

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None Observed

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-15-2023

Boring Completed
02-15-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-10

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 44.5116° Longitude: -109.0818° Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	
2		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous *(continued)*				28-36-43 N=79				4.2			
			30			41-50/4"				4.5			
			35			50/1"							
		40.2	40			50/2"				5.4			
		Boring Terminated at 40.2 Feet											

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-15-2023

Boring Completed
02-15-2023

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-11

Location: See Exploration Plan

Latitude: 44.5116° Longitude: -109.0821°

Model Layer	Depth (Ft.)	Material Description	Sample Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (psf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, moist, medium dense to dense, homogeneous	0-1.5			9-9-6 N=15				15.4		
			2.5-4			7-10-13 N=23				10.4		
	6.5		5-6.5			7-13-17 N=30				5.5		
2		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous	7.5-9			24-26-25 N=51				6.1		
			10			50/1"						
			15			50/1"						
			20-21			27-50/5"				4.8		

Depth scale: 5, 10, 15, 20, 25

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None Observed

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-14-2023

Boring Completed
02-15-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-11

Location: See Exploration Plan

Latitude: 44.5116° Longitude: -109.0821°

Model Layer	Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	
2			**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous *(continued)*				12-22-24 N=46				5.0			
				30			6-26-50/4"				5.8			
				35			19-50/5"				6.9			
		41.0		40			28-30-50/5"				7.1			
4		41.5	**CLAYSTONE**, tan, dry, fine-grained, moderately fractured, close fracture spacing, thin bedding, highly weathered, weak rock, trace of gravel and sand											

Boring Terminated at 41.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Logged by
TJ Trussell

Boring Started
02-14-2023

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Boring Completed
02-15-2023

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. B-12

Location: See Exploration Plan

Latitude: 44.5118° Longitude: -109.0819°

Model Layer	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		**WELL GRADED GRAVEL WITH SAND (GW)**, fine grained, subangular, brown, moist, medium dense to dense, homogeneous	0–1.5		X	5-6-5 N=11				13.5		
			2.5–4		X	7-11-11 N=22				4.3		
			5–6.5		X	30-30-18 N=48				4.1		
			7.5–8.9		X	14-33-50/5"				3.6		
	11.0		10–11.4		X	23-46-50/5"				2.9		NP
2		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, brown, dry, very dense, homogeneous, auger refusal at 18 feet	15–15.9		X	41-50/5"				3.6		
	18.0											

Auger Refusal at 18 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Logged by
TJ Trussell

Boring Started
02-13-2023

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Boring Completed
02-14-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. P-6

Location: See Exploration Plan

Latitude: 44.5116° Longitude: -109.0806°

Model Layer	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	
1		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, dry, medium dense to dense, homogeneous			X	11-19-12 N=31				9.6			
					X	8-10-16 N=26				4.7			
			5		X	23-22-18 N=40				2.9			
		very dense			X	50/5"				2.5			
	10.8		10		X	23-50/4"				2.1			

Boring Terminated at 10.8 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-17-2023

Boring Completed
02-17-2023

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. P-7

Location: See Exploration Plan

Latitude: 44.5112° Longitude: -109.0806°

Model Layer	Graphic Log	Description / Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	
3		**SANDY FAT CLAY (CH)**, medium to high plasticity, brown, moist, very stiff				9-11-8 N=19				12.2			
						9-12-17 N=29				11.2			
		4.0											
1		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brownish tan, dry, very dense, homogeneous	5			28-35-50/5"				2.4			
						11-23-50/5"				3.0			
			10			24-50/4"				1.8			
		10.8											
		Boring Terminated at 10.8 Feet											

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-17-2023

Boring Completed
02-17-2023

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. P-8

Location: See Exploration Plan

Latitude: 44.5112° Longitude: -109.0808°

Model Layer	Graphic Log	Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
3		**SANDY FAT CLAY (CH)**, medium to high plasticity, brown, moist, stiff to very stiff				5-7-8 N=15				14.8		
						8-7-7 N=14				15.0		
		5.0	5									
1		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, dry, dense to very dense, homogeneous				16-19-17 N=36				4.0		
						22-43-50/5"				2.9		
		10.4	10			50/5"				3.6		

Boring Terminated at 10.4 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-17-2023

Boring Completed
02-17-2023

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. P-9

Location: See Exploration Plan

Latitude: 44.5111° Longitude: -109.0816°

Model Layer	Graphic Log	Depth (Ft.) / Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
3		**SANDY FAT CLAY (CH)**, medium to high plasticity, brown, moist, stiff				5-6-5 N=11				11.9		
							UC	1708	1.2	16.3	106	50-22-28
			5			4-5-4 N=9				13.0		
		7.5										
1		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, dry, very dense, homogeneous				17-27-34 N=61				2.8		
			10			21-23-31 N=54				4.1		
		11.5										
		Boring Terminated at 11.5 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations were obtained from Google Earth

Water Level Observations

None

Observed

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-17-2023

Boring Completed
02-17-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. P-10

Location: See Exploration Plan

Latitude: 44.5109° Longitude: -109.0816°

Model Layer	Depth (Ft.)	Description	Sample Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
3		**SANDY FAT CLAY (CH)**, medium to high plasticity, brown, moist, stiff			Split spoon	7-9-6 N=15				13.0		
					Split spoon	6-7-7 N=14				12.1		
1	5.5	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine grained, subangular, brown, dry, very dense, homogeneous	5		Split spoon	5-14-49 N=63				15.5		
					Split spoon	25-34-36 N=70				2.8		
	11.4		10		Split spoon	12-25-50/5"				3.5		NP

Boring Terminated at 11.4 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations were obtained from Google Earth

Water Level Observations

None

Observed

Advancement Method

HSA

Abandonment Method

Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-16-2023

Boring Completed
02-16-2023

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. RW-1

Location: See Exploration Plan

Latitude: 44.5120° Longitude: -109.0825°

Model Layer	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (psf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		**SILTY GRAVEL WITH SAND (GM)**, fine grained, subangular to subrounded, brown, moist to dry, medium dense			X	7-7-13 N=20				10.1		
					X	6-6-4 N=10				4.5		
			5		X	6-6-6 N=12				3.3		
2	7.5	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, light brown, dry, very dense to dense, homogeneous			X	14-16-19 N=35				3.2		
			10		X	18-26-32 N=58				3.2		
			15		X	15-17-25 N=42				3.1		
	21.5		20		X	24-19-15 N=34				4.7		

Boring Terminated at 21.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
TJ Trussell

Boring Started
02-16-2023

Boring Completed
02-16-2023

2110 Overland Ave Ste 124
Billings, MT

Boring Log No. RW-2

Location: See Exploration Plan

Latitude: 44.5120° Longitude: -109.0928°

Model Layer	Depth (Ft.)	Description	Field Test Results	Water Content (%)
1	0–7.5	**SILTY GRAVEL WITH SAND (GM)**, fine grained, subangular to subrounded, brown, moist to dry, medium dense	6-12-12 N=24	9.4
			7-7-5 N=12	2.8
			7-10-20 N=30	4.6
2	7.5–21.5	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, light brown, dry, very dense to dense, homogeneous	21-26-39 N=65	2.7
			23-29-50/5"	3.7
			31-50/5"	3.1
			49-27-16 N=43	

Columns also present (no entries): Water Level Observations, Test Type, Compressive Strength (psf), Strain (%), Dry Unit Weight (pcf), Atterberg Limits LL-PL-PI.

Boring Terminated at 21.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None Observed

Notes
Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-16-2023

Boring Completed
02-16-2023

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. RW-3

Location: See Exploration Plan

Latitude: 44.5122° Longitude: -109.0822°

Model Layer	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1	5.0	**SILTY GRAVEL WITH SAND (GM)**, fine grained, subangular to subrounded, brown, moist to dry, loose to medium dense				8-8-8 N=16				7.6		
						5-2-4 N=6				4.3		NP
2	21.5	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, light brown, dry, dense to very dense, homogeneous	5			6-5-6 N=11						
						18-16-18 N=34				3.3		
			10			11-23-41 N=64				3.4		NP
		hard drilling from 15-20 feet	15			21-26-30 N=56				2.8		
		medium dense	20			13-8-7 N=15				6.0		

Boring Terminated at 21.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None
Observed

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

Boring Started
02-16-2023

Boring Completed
02-16-2023

Notes

Elevation Reference: Elevations were obtained from Google Earth

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
2110 Overland Ave Ste 124
Billings, MT

Boring Log No. RW-4

Location: See Exploration Plan

Latitude: 44.5122° Longitude: -109.0819°

Model Layer	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1	7.5	**SILTY GRAVEL WITH SAND (GM)**, fine grained, subangular to subrounded, brown, moist to dry, medium dense			X	7-9-10 N=19				22.3		
					X	7-7-5 N=12				7.5		
			5		X	4-6-6 N=12						
2	21.5	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, with cobbles, coarse grained, subrounded, light brown, dry, medium dense to very dense, homogeneous			X	11-11-18 N=29				2.8		
			10		X	18-34-50/2"				8.1		
			15		X	12-12-14 N=26				3.3		
			20		X	32-23-22 N=45				2.5		

Boring Terminated at 21.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes
Elevation Reference: Elevations were obtained from Google Earth

Water Level Observations
None
Observed

Advancement Method
HSA

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
BK-81

Hammer Type
Automatic

Driller
Haztech / P. Bray

Logged by
TJ Trussell

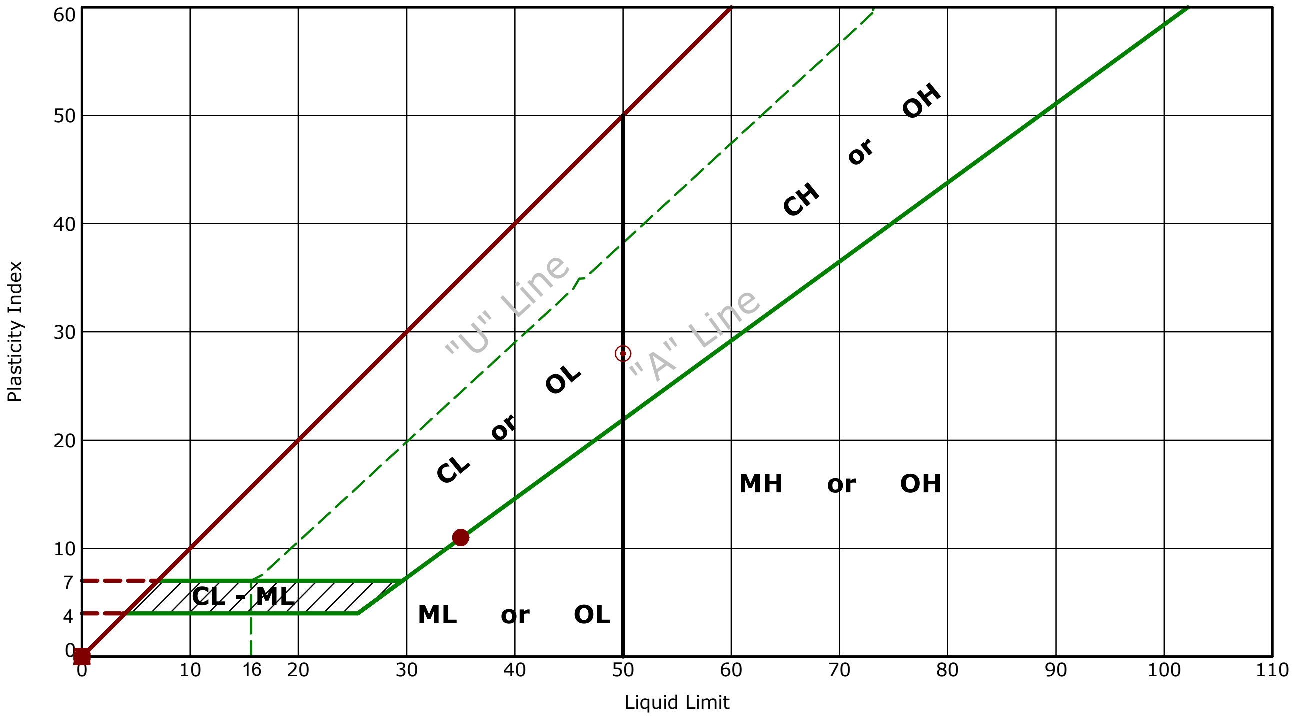
Boring Started
02-16-2023

Boring Completed
02-16-2023

2110 Overland Ave Ste 124
Billings, MT

Atterberg Limit Results

ASTM D4318

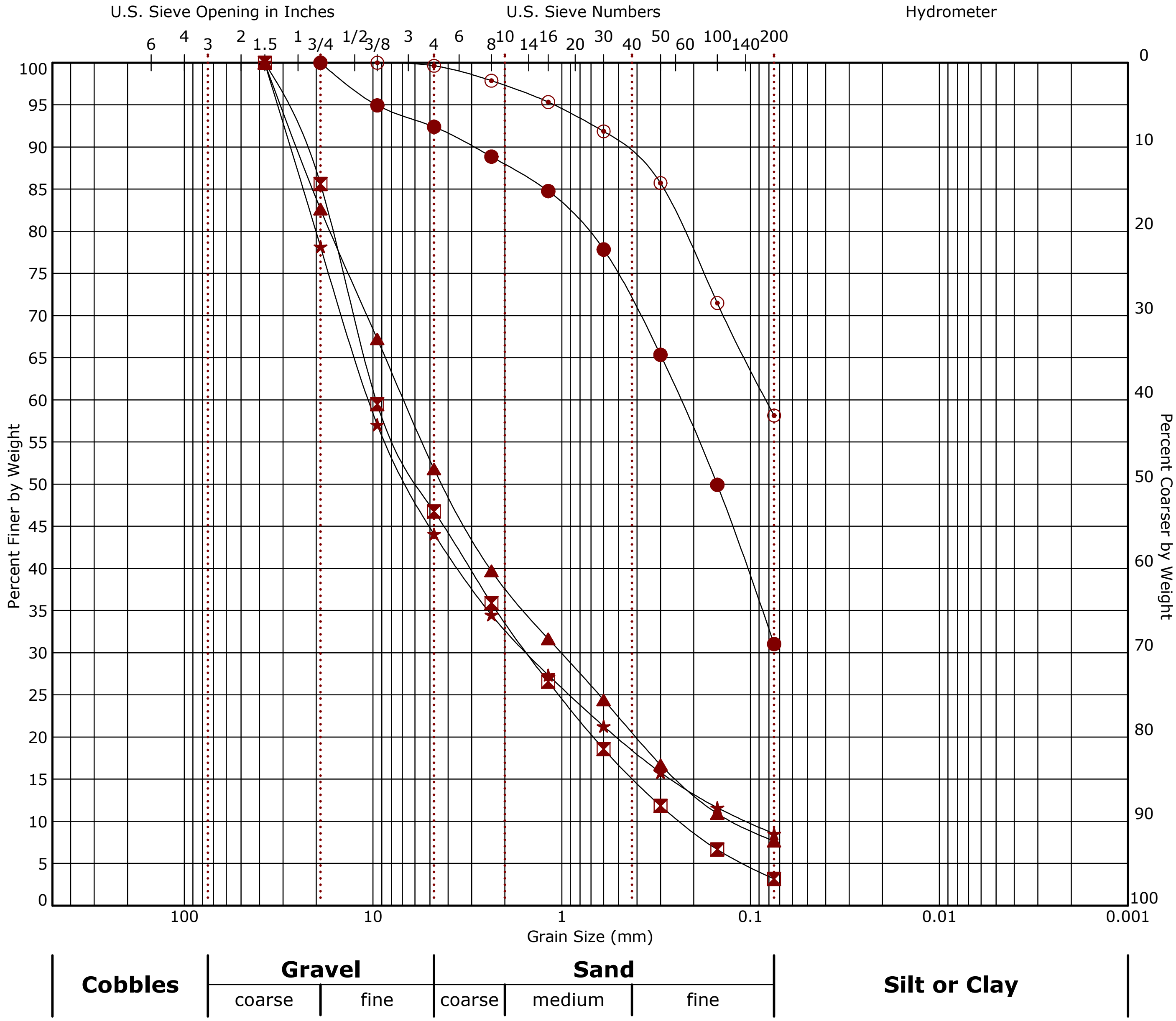


	Boring ID	Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	B-10	0 - 1.5	35	24	11	31.0	SC	CLAYEY SAND
⊠	B-12	10 - 11.4	NP	NP	NP	3.2	GW	WELL-GRADED GRAVEL with SAND
▲	B-8	5 - 6.5	NP	NP	NP	7.6	GW-GM	WELL-GRADED GRAVEL with SILT and SAND
★	P-10	10 - 11.4	NP	NP	NP	8.5	GW-GM	WELL-GRADED GRAVEL with SILT and SAND
⊙	P-9	2.5 - 4.5	50	22	28	58.1	CH	SANDY FAT CLAY
✤	RW-3	2.5 - 4	NP	NP	NP	12.5	GM	SILTY GRAVEL with SAND
○	RW-3	10 - 11.5	NP	NP	NP	5.5	GP-GM	POORLY GRADED GRAVEL with SILT and SAND

Terracon
2110 Overland Ave Ste 124
Billings, MT

Grain Size Distribution

ASTM D422 / ASTM C136



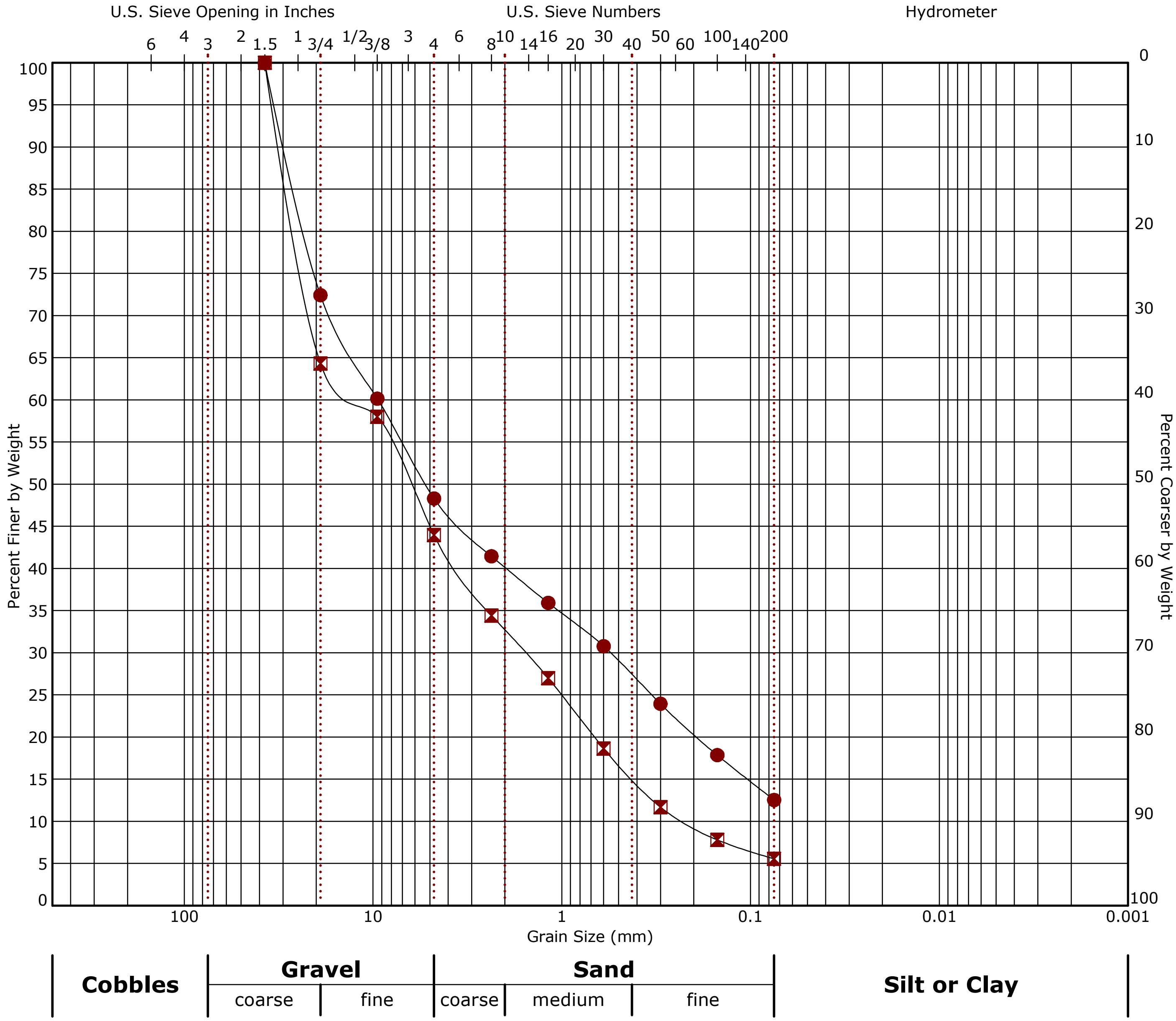
	Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
●	B-10	0 - 1.5	CLAYEY SAND	SC	A-2-6 (0)	35	24	11		
⊠	B-12	10 - 11.4	WELL-GRADED GRAVEL with SAND	GW	A-1-a (0)	NP	NP	NP	1.03	41.10
▲	B-8	5 - 6.5	WELL-GRADED GRAVEL with SILT and SAND	GW-GM	A-1-a (0)	NP	NP	NP	1.21	55.69
★	P-10	10 - 11.4	WELL-GRADED GRAVEL with SILT and SAND	GW-GM	A-1-a (0)	NP	NP	NP	2.13	100.23
⊙	P-9	2.5 - 4.5	SANDY FAT CLAY	CH	A-7-6 (13)	50	22	28		

	Boring ID	Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	B-10	0 - 1.5	19	0.236			0.0	7.6	61.4	31.0		
⊠	B-12	10 - 11.4	37.5	9.631	1.524	0.234	0.0	53.2	43.6	3.2		
▲	B-8	5 - 6.5	37.5	6.868	1.011	0.123	0.0	48.2	44.2	7.6		
★	P-10	10 - 11.4	37.5	10.465	1.525	0.104	0.0	55.9	35.6	8.5		
⊙	P-9	2.5 - 4.5	9.5	0.083			0.0	0.4	41.5	58.1		

Terracon
2110 Overland Ave Ste 124
Billings, MT

Grain Size Distribution

ASTM D422 / ASTM C136



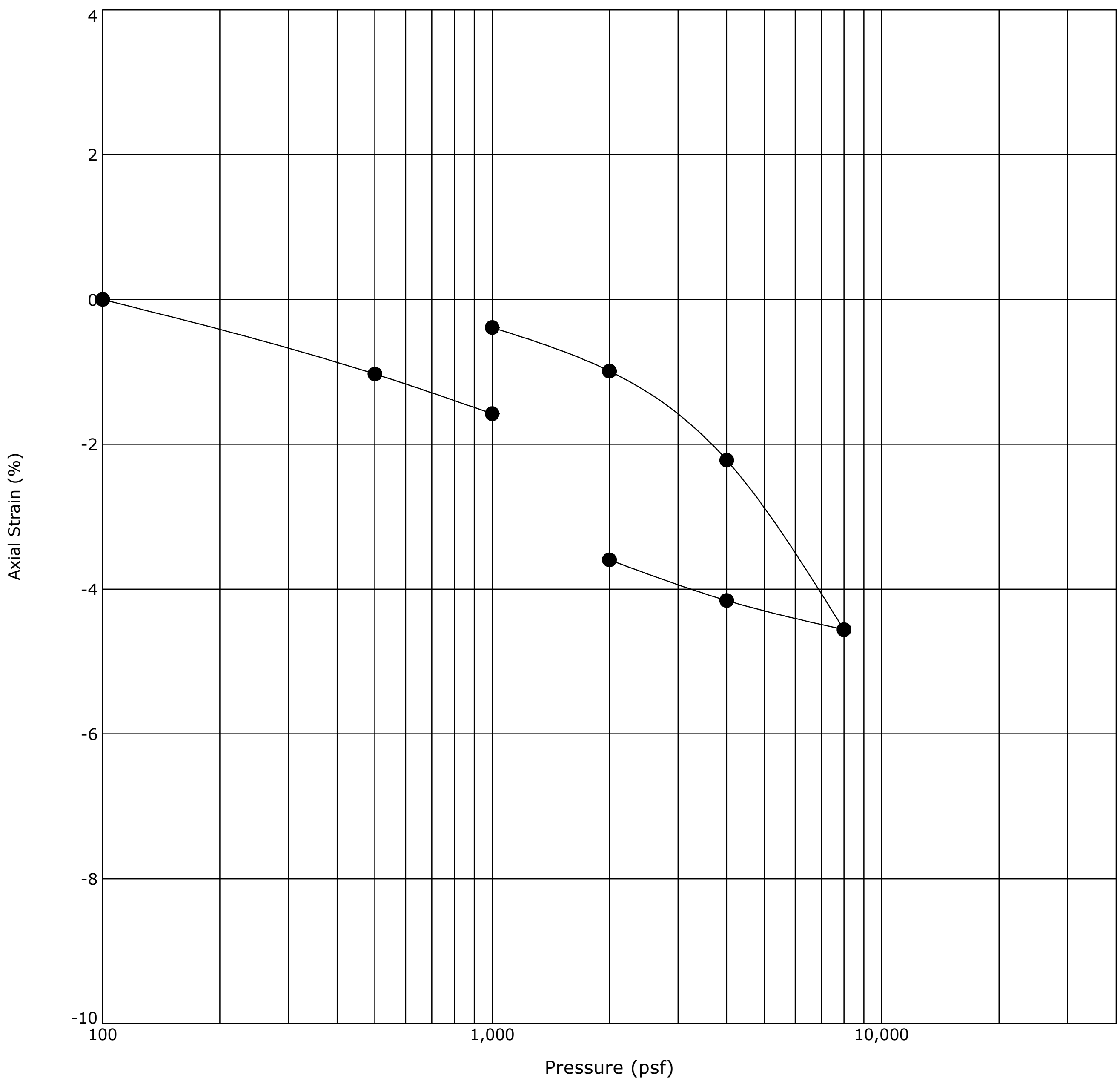
Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
● RW-3	2.5 - 4	SILTY GRAVEL with SAND	GM	A-1-a (0)	NP	NP	NP		
⊠ RW-3	10 - 11.5	POORLY GRADED GRAVEL with SILT and SAND	GP-GM	A-1-a (0)	NP	NP	NP	0.93	53.32

Boring ID	Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● RW-3	2.5 - 4	37.5	9.421	0.555		0.0	51.7	35.8	12.5		
⊠ RW-3	10 - 11.5	37.5	11.838	1.563	0.222	0.0	56.0	38.4	5.5		

2110 Overland Ave Ste 124
Billings, MT

Swell Consolidation Test

ASTM D2435



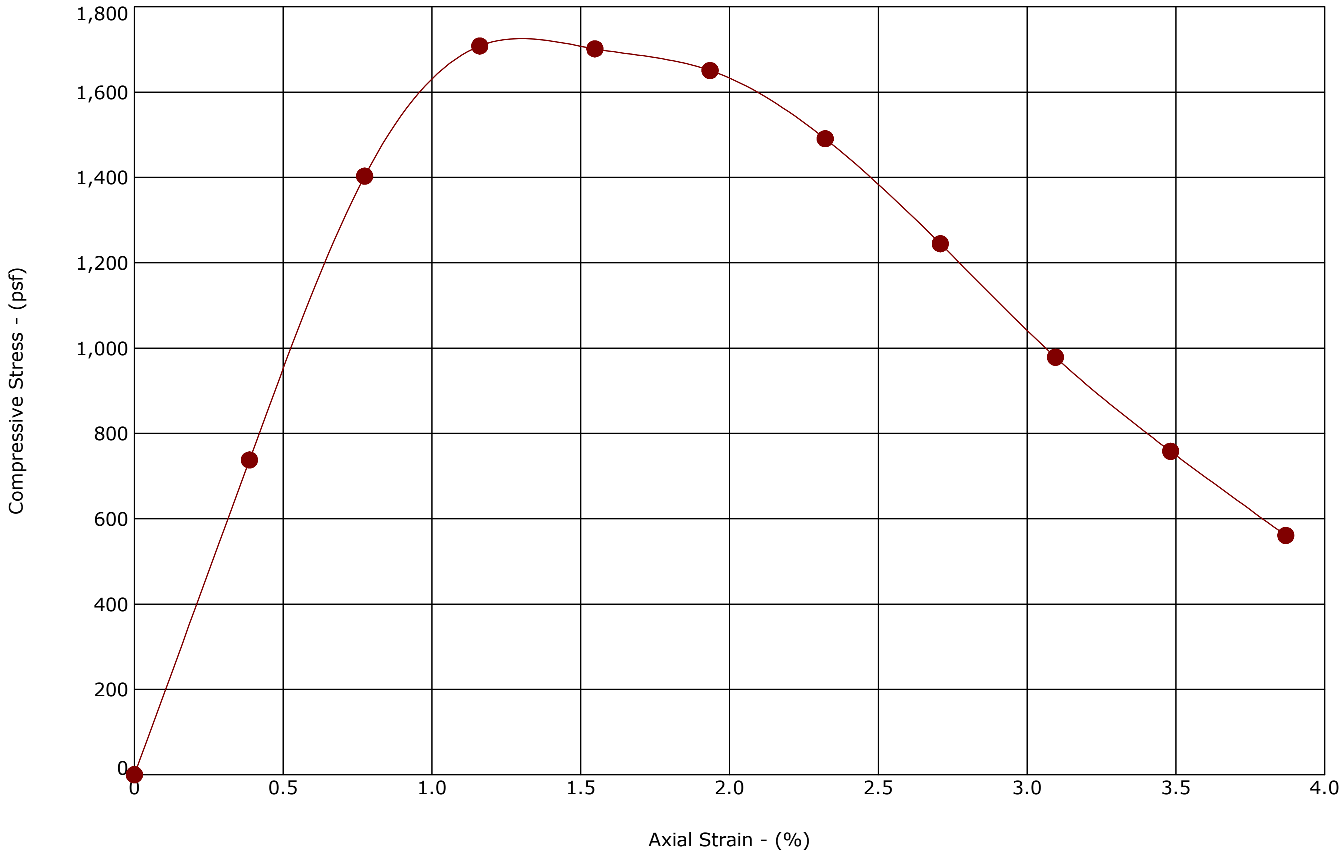
Boring ID		Depth (Ft)	Description	USCS	γ_d(pcf)	WC (%)
●	P-9	2.5 - 4.5	SANDY FAT CLAY	CH	107	16.3

Notes: Sample inundated at 1000 psf

Terracon
2110 Overland Ave Ste 124
Billings, MT

Unconsolidated-Undrained Test

ASTM D2850



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
P-9	2.5 - 4.5	Shelby Tube	50	22	28	58.1	SANDY FAT CLAY(CH)

Specimen Failure Mode

Specimen Test Data

Moisture Content (%):	16.3
Dry Density (pcf)	106.3
Diameter (in):	2.86
Height (in):	5.17
Height / Diameter Ratio:	1.81
Calculated Saturation (%)	
Calculated Void Ratio:	
Assumed Specific Gravity:	
Failure Strain (%):	1.16
Compressive Strength (psf):	1708
Undrained Shear Strength (psf):	854
Strain Rate (in/min):	
Cell Pressure (psi):	
Remarks:	

ANALYTICAL SUMMARY REPORT

March 08, 2023

Terracon Consultants
2110 Overland Ave Ste 124
Billings , MT 59102-6440

Work Order: B23021678 Quote ID: B5647

Project Name: Cody Site

Energy Laboratories Inc Billings MT received the following 1 sample for Terracon Consultants on 2/28/2023 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B23021678-001	RW-3 2.5-4		02/28/23	Soil	Anions, Saturated Paste Extract pH, Saturated Paste Saturated Paste Extraction ASA Resistivity, Sat Paste

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the report package. Any issues encountered during sample receipt are documented in the Work Order Receipt Checklist.

The results as reported relate only to the item(s) submitted for testing. This report shall be used or copied only in its entirety. Energy Laboratories, Inc. is not responsible for the consequences arising from the use of a partial report.

If you have any questions regarding these test results, please contact your Project Manager.

Report Approved By:

Sonya Mallett
Soil Department Supervisor
Digitally signed by Sonya Mallett
Date: 2023.03.08 12:17:37 -07:00

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Terracon Consultants	**Report Date:**	03/08/23
Project:	Cody Site	**Collection Date:**	Not Provided
Lab ID:	B23021678-001	**DateReceived:**	02/28/23
Client Sample ID:	RW-3 2.5-4	**Matrix:**	Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SATURATED PASTE EXTRACT							
Resistivity, Sat. Paste	407	ohm-cm		1		Calculation	03/07/23 16:02 / srm
pH, sat. paste	7.5	s.u.		0.1		ASA10-3	03/07/23 16:02 / srm
Sulfate	1090	mg/L		1		E300.0	03/07/23 17:36 / caa

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Terracon Consultants **Work Order:** B23021678 **Report Date:** 03/08/23

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA10-3									Batch: R398607	
Lab ID: B23021657-001A DUP		Sample Duplicate				Run: MISC-SOIL_230307B			03/07/23 16:02	
pH, sat. paste		8.20	s.u.	0.10				1.2	10	
Lab ID: LCS-2303071602		Laboratory Control Sample				Run: MISC-SOIL_230307B			03/07/23 16:02	
pH, sat. paste		7.10	s.u.	0.10	95	90	110			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Terracon Consultants **Work Order:** B23021678 **Report Date:** 03/08/23

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: Calculation									Batch: R398607	
Lab ID: B23021657-001A DUP		Sample Duplicate				Run: MISC-SOIL_230307B			03/07/23 16:02	
Resistivity, Sat. Paste		1980	ohm-cm	1.0		70	130	4.1	30	
Lab ID: LCS-2303071602		Laboratory Control Sample				Run: MISC-SOIL_230307B			03/07/23 16:02	
Resistivity, Sat. Paste		190	ohm-cm	1.0	89	70	130			

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Terracon Consultants **Work Order:** B23021678 **Report Date:** 03/08/23

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E300.0										Batch: 176542
Lab ID: LCS-176542		Laboratory Control Sample				Run: IC METROHM 2_230306A				03/07/23 17:19
Sulfate		2040	mg/L	2.0	102	70	130			
Lab ID: B23021678-001AMS		Sample Matrix Spike				Run: IC METROHM 2_230306A				03/07/23 17:53
Sulfate		2210	mg/L	1.1	112	70	130			
Lab ID: B23030259-001ADUP		Sample Duplicate				Run: IC METROHM 2_230306A				03/07/23 19:00
Sulfate		24.0	mg/L	1.0				3.0	30	

Qualifiers:

RL - Analyte Reporting Limit

ND - Not detected at the Reporting Limit (RL)

Work Order Receipt Checklist

Terracon Consultants B23021678

Login completed by:	Lyndsi E. LeProwse	Date Received:	2/28/2023
Reviewed by:	gmccartney	Received by:	lel
Reviewed Date:	3/3/2023	Carrier name:	Hand Deliver

Shipping container/cooler in good condition?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☐	No ☑	Not Applicable ☐
Container/Temp Blank temperature:	19.1°C No Ice		
Containers requiring zero headspace have no headspace or bubble that is <6mm (1/4").	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

The reference date for Radon analysis is the sample collection date. The reference date for all other Radiochemical analyses is the analysis date. Radiochemical precision results represent a 2-sigma Total Measurement Uncertainty.

Contact and Corrective Action Comments:

None

ENERGY LABORATORIES
Trust our People. Trust our Data.

Chain of Custody & Analytical Request Record

www.energylab.com

Page 1 of 1

Account Information (Billing information)

Company/Name	Terracon Consultants
Contact	Matthew Hoffmann
Phone	406-453-5400
Mailing Address	1392 13th Ave SW
City, State, Zip	Great Falls, MT 59404
Email	Matthew.Hoffmann@terracon.com
Receive Invoice	☐Hard Copy ☑Email
Receive Report	☐Hard Copy ☑Email
Purchase Order	26235004
Quote	
Bottle Order	

Report Information (if different than Account Information)

Company/Name	Same as left
Contact	
Phone	
Mailing Address	
City, State, Zip	
Email	
Receive Report	☐Hard Copy ☐Email
Special Report/Formats:	☐ LEVEL IV ☐ NELAC ☐ EDD/EDT (contact laboratory) ☐ Other

Comments

Project Information

Project Name, PWSID, Permit, etc.	Cody Site
Sampler Name	
Sampler Phone	
Sample Origin State	
EPA/State Compliance	☐ Yes ☐ No
Lab provided preservatives were used	☐ Yes ☐ No

MINING CLIENTS, please indicate sample type.
*If ore has been processed or refined, call before sending.
☐ Byproduct 11 (e)2 material ☐ Unprocessed ore (NOT ground or refined)*

Matrix Codes
A - Air
W - Water
S - Soils/Solids
V - Vegetation
B - Bioassay
O - Other
DW - Drinking Water

All turnaround times are standard unless marked as RUSH.
Energy Laboratories MUST be contacted prior to RUSH sample submittal for charges and scheduling – See Instructions Page

Analysis Requested

	Sample Identification (Name, Location, Interval, etc.)	Collection Date	Collection Time	Number of Containers	Matrix (See Codes Above)	pH/Sulfate/Resistivity										See Attached	RUSH TAT	ELI LAB ID Laboratory Use Only
1	RW-3@2.5-4'			1	S	S												B23021678
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

Custody Record MUST be signed					
Relinquished by (print)	Tyler J. Trussell	Date/Time	2/29/23 3:49pm	Signature	Tyler J. Trussell
Relinquished by (print)		Date/Time		Signature	
Received by (print)		Date/Time		Signature	
Received by Laboratory (print)	Lynda LeRouse	Date/Time	2/28/23 15:49	Signature	Lynda LeRouse

LABORATORY USE ONLY

Shipped By	Cooler ID(s)	Custody Seals	Intact	Receipt Temp	Temp Blank	On Ice	Payment Type	Amount	Receipt Number (cash/check only)
		Y N C B	Y N	°C	Y N	Y N	CC Cash Check ____	$	

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.

ELI-COC-06/08 v.2

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
2110 Overland Ave Ste 124
Billings, MT

General Notes

Sampling	Water Level	Field Tests
Grab Sample Shelby Tube Split Spoon	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time Cave In Encountered Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N — Standard Penetration Test Resistance (Blows/Ft.) (HP) — Hand Penetrometer (T) — Torvane (DCP) — Dynamic Cone Penetrometer UC — Unconfined Compressive Strength (PID) — Photo-Ionization Detector (OVA) — Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**Consistency of Fine-Grained Soils** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

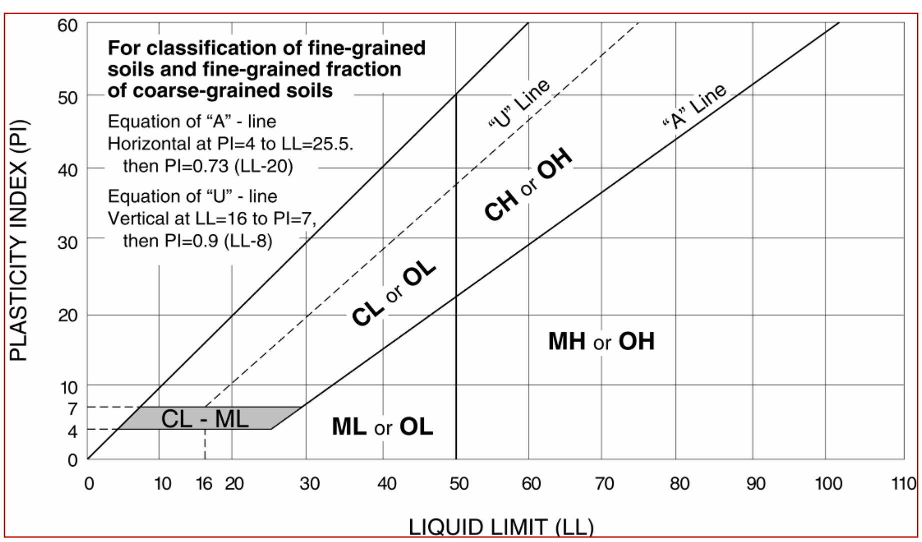
Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	**Group Name** [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Rock Classification Notes

WEATHERING	
Term	**Description**
Fresh	Mineral crystals appear bright; show no discoloration. Features show little or now staining on surfaces. Discoloration does not extend into intact rock.
Slightly weathered	Rock generally fresh except along fractures. Some fractures stained and discoloration may extend <0.5 inches into rock.
Moderately weathered	Significant portions of rock are dull and discolored. Rock may be significantly weaker than in fresh state near fractures. Soil zones of limited extent may occur along some fractures.
Highly weathered	Rock dull and discolored throughout. Majority of rock mass is significantly weaker and has decomposed and/or disintegrated; isolated zones of stronger rock and/or soil may occur throughout.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The rock mass or fabric is still evident and largely intact. Isolated zones of stronger rock may occur locally.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi**
Extremely strong	Can only be chipped with geological hammer. Rock rings on hammer blows. Cannot be scratched with a sharp pick. Hand specimens require several hard hammer blows to break.	>36,000
Very strong	Several blows of a geological hammer to fracture. Cannot be scratched with a 20d common steel nail. Can be scratched with a geologist's pick only with difficulty.	15,000-36,000
Strong	More than one blow of a geological hammer needed to fracture. Can be scratched with a 20d nail or geologist's pick. Gouges or grooves to ¼ inch deep can be excavated by a hard blow of a geologist's pick. Hand specimens can be detached by a moderate blow.	7,500-15,000
Medium strong	One blow of geological hammer needed to fracture. Can be distinctly scratched with 20d nail. Can be grooved or gouged 1/16 in. deep by firm pressure with a geologist's pick point. Can be fractured with single firm blow of geological hammer. Can be excavated in small chips (about 1-in. maximum size) by hard blows of the point of a geologist's pick;	3,500-7,500
Weak	Shallow indent by firm blow with geological hammer point. Can be gouged or grooved readily with geologist's pick point. Can be excavated in pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.	700-3,500
Very weak	Crumbles under firm blow with geological hammer point. Can be excavated readily with the point of a geologist's pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.	150-700

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Intensely fractured	< 2.5 inches	**Laminated**	< ½-inch
Highly fractured	2.5 – 8 inches	**Very thin**	½ – 2 inches
Moderately fractured	8 inches to 2 feet	**Thin**	2 inches – 1 foot
Slightly fractured	2 to 6.5 feet	**Medium**	1 – 3 feet
Very slightly fractured	> 6.5 feet	**Thick**	3 – 10 feet
		Massive	> 10 feet

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.